CLAIMS

What is claimed is:

1. A fuel staging valve assembly, for distributing fuel flow to a multiple zone nozzle in a gas turbine engine, comprised of a pilot valve operatively interconnected with at least one main valve, said at least one main valve comprising:

a. a dual diameter valve housing;

b. a dual diameter cylindrical valve sleeve fixedly, sealingly and conformably received within said valve housing, said sleeve having a first diameter portion and a second diameter portion joined via an intermediate annular portion, with a peripheral land cavity being located between said sleeve intermediate portion and an adjacent portion of said valve housing; and said first diameter portion having a peripheral, recessed, annular gland area with axially spaced first and second pluralities of discrete radial passages therethrough;

c. a dual diameter hollow cylindrical valve spool, having a central cavity in communication with a source of fuel, conformably and slidably received within said cylindrical valve sleeve, said spool having a first diameter portion and a second diameter portion joined via an intermediate annular portion, with predetermined diametral clearance spaces being provided between corresponding adjoining first and second diameter portions of said sleeve and spool, thereby permitting a predetermined amount of fluid leakage therebetween, during operation of said pilot poppet valve; and an annular pressure signal cavity, interconnected with said land cavity, being located between intermediate annular portions of said valve sleeve and said valve spool;

d. a centrally apertured spring retainer fixedly received within said sleeve first diameter portion and closing one end thereof;

e. a main valve spring, interposed between said spring retainer and said spool intermediate annular portion, for preloading said spool against said sleeve;

f. a centrally-apertured dual diameter valve seat retainer member having a first diameter portion and a second diameter portion joined via an intermediate radial surface portion, said retainer member first diameter portion being fixedly and sealingly received within an open end of said sleeve second diameter portion, with said retainer member intermediate radial surface portion being provided with an inwardly-directed, raised, central contoured seal seat portion adjoining said retainer member second diameter portion;

g. a generally cup-shaped closure member is fixedly and sealingly received on said retainer member second diameter portion and includes a central main valve discharge orifice adapted to be operatively interconnected with said nozzle;

h. a multiple diameter poppet member having interconnected first, second and third diameter portions, said first diameter portion being yieldingly, slidably received within an open end of said valve spool second diameter portion, with the axial movement of said poppet member being restricted via a split retaining roll pin press-fitted relative to said valve spool second diameter portion but having a predetermined peripheral clearance relative to said poppet member;

i. a poppet spring, operatively interposed between said poppet member and a peripheral internal wall portion in said spool member second diameter portion, for axially biasing said poppet member toward said contoured seal seat portion, with said biasing being limited via said predetermined axial clearance, relative to said roll pin;

j. a stiff, elastic, annular seal member, contoured in cross-section, fixedly retained within a mating contoured recess within said poppet member second diameter portion, having an axial outer surface adapted to sealingly mate with said raised valve seat portion of said valve seat retainer

member, with said third diameter portion of said poppet member, in an at-rest position, axially extending, beyond said seal member axial outer surface and in the vicinity of said seal seat portion, with at least one predetermined diametral clearance, into said retainer member second diameter portion; and

k. a shim, fixedly abutting and acting on said retainer member intermediate radial surface portion, provides an initial, predetermined sealing force, relative to said seal member axial outer surface, against said retaining roll pin, thereby preventing fuel leaks at low fluid supply pressure, with said predetermined peripheral clearance, relative to said poppet member serving to limit the compression of said elastic seal member as well as allowing compensating for any seal compression set.

2. The fuel staging valve assembly of claim 1, wherein said axial outer surface of said elastic, annular seal member is one of being generally flattened, contoured, stepped and relieved, via surface finishing, after being fixedly retained within said recess.

3. The fuel staging valve assembly of claim 1, wherein said elastic, annular seal member is fixedly retained within a matingly contoured annular recess located in said poppet member second diameter portion, said seal member being one of bonded, molded-in-place and cast-in-place.

4. The fuel staging valve assembly of claim 3, wherein at least one of said contoured recess and seal member has, in cross-section, an at least partial dovetail shape.

5. The fuel staging valve assembly of claim 1, wherein said elastic, annular seal member is comprised of a stiff rubber-based composition having an approximate 90 durometer hardness.

6. The fuel staging valve assembly of claim 1, wherein said contoured valve seat portion is one of gradually tapering, semicircular and of a double inwardly-tapering shape.

7. The fuel staging valve assembly of claim 1, wherein said predetermined diametral clearance spaces between said corresponding first and second diameter portions of said valve sleeve and valve spool are located in at least one of the mutually adjoining sleeve inner wall and spool outer wall surfaces.

8. The fuel staging valve assembly of claim 7, wherein said diametral clearance spaces function as predetermined, controlled, leakage paths through which a high pressure signal fluid can flow, via a fluid signal pressure conduit connected with said peripheral land cavity, from said high pressure signal cavity to adjoining areas of lower pressure between said valve sleeve and said valve spool via at least one further intermediate aperture and said diametral clearance spaces.

9. The fuel staging valve assembly of claim 8, wherein the percentage of fluid leakage is below about 2 percent of the total fluid flow within said assembly.

10. The fuel staging valve assembly of claim 1, wherein all axially movable components of said main valve are located upstream of said valve seat retainer member, in a direction opposite to the flow of fuel exiting from said discharge orifice, said axially movable components thereby being protected from combustion products produced during operation of said gas turbine engine.

11. The fuel staging valve assembly of claim 10, wherein said axially movable components include said valve spool, said main valve spring, said poppet member, said poppet spring and said seal member.

12. The fuel staging valve assembly of claim 1, wherein said main valve centrally apertured spring retainer includes an inner annular end portion, having a plurality of spaced radial passages, at a location generally radially inwardly of said annular gland area, said retainer annular end portion, during certain predetermined operating positions of said staging valve assembly, being axially spaced differing distances, relative to said main valve spool.

13. The fuel staging valve assembly of claim 12, wherein during at least one of said certain predetermined operating positions of said staging valve assembly, one of said axially spaced first and second pluralities of discrete radial passages is blocked by said main valve spool first diametral portion.

14. The fuel staging valve of claim 1, further including a fluid inlet plate, having a central cylindrical portion extending through said centrally apertured spring retainer into said cylindrical cavity, said fluid inlet plate being interposed between said spring retainer and a retaining ring in said main valve sleeve first cylindrical portion, said inlet plate cylindrical portion serving as an inlet for said fuel into said main valve.

15. The fuel staging valve of claim 14, further including a fuel strainer having a closed end and an open end, said open end being affixed to said inlet plate cylindrical portion, said fuel strainer extending into the central interior cavity of said main valve.

16. The fuel staging valve assembly of claim 1, said pilot valve comprising:

a. a dual diameter valve housing;

b. a dual diameter cylindrical valve sleeve fixedly, sealingly and conformably received within said valve housing, said valve sleeve having a first diameter portion and a second diameter portion joined via an intermediate annular portion, with a peripheral land cavity being located between said

sleeve intermediate portion and an adjacent portion of said valve housing; and said first diameter portion having a peripheral, recessed, annular gland area with a plurality of discrete radial passages therethrough ;

c. a dual diameter hollow cylindrical valve spool, having a central cavity, conformably and slidably received within said cylindrical valve sleeve, said spool having a first diameter portion and a second diameter portion joined via an intermediate annular portion, with predetermined diametral clearance spaces being provided between corresponding adjoining first and second diameter portions of said sleeve and spool, thereby permitting a predetermined amount of fluid leakage therebetween, during operation of said pilot poppet valve; and an annular pressure signal cavity, interconnected with said land cavity, being located between annular portions of said valve sleeve and said valve spool;

d. a spring retainer fixedly and sealingly received within said sleeve first diameter portion and closing one end thereof;

e. a pilot valve spring, interposed between said spring retainer and said spool intermediate annular portion, for preloading said spool against said sleeve;

f. a centrally-apertured dual diameter valve seat retainer member having a first diameter portion and a second diameter portion joined via an intermediate radial surface portion, said retainer member first diameter portion being fixedly and sealingly received within an open end of said sleeve second diameter portion, with said retainer member intermediate radial surface portion being provided with an inwardly-directed, raised, central contoured seal seat portion adjoining said retainer member second diameter portion;

g. a generally cup-shaped closure member is fixedly and sealingly received on said retainer member second diameter portion and includes a central pilot valve discharge orifice adapted to be operatively interconnected with said nozzle;

h. a dual diameter poppet member having a first diameter portion and a second diameter portion, said first diameter portion being yieldingly, slidably

received within an open end of said valve spool second diameter portion, with the axial movement of said poppet member being restricted via a split retaining roll pin press-fitted relative to said valve spool second diameter portion but having a predetermined peripheral clearance relative to said poppet member;

i. a poppet spring, operatively interposed between said poppet member and a peripheral internal wall portion in said spool member second diameter portion, for axially biasing said poppet member toward said contoured seal seat portion, with said biasing being limited via said predetermined axial clearance, relative to said roll pin;

j. a stiff, elastic, annular seal member, contoured in cross-section, fixedly retained within a mating contoured recess within said poppet member second diameter portion, having an axial outer surface adapted to sealingly mate with said raised valve seat portion of said valve seat retainer member; and

k. a shim, fixedly abutting and acting on said said retainer member intermediate radial surface portion, provides an initial, predetermined sealing force, relative to said seal member axial outer surface, against said retaining roll pin, thereby preventing fuel leaks at low fluid supply pressure, with said predetermined peripheral clearance, relative to said poppet member serving to limit the compression of said elastic seal member as well as allowing compensating for any seal compression set.

17. The fuel staging valve assembly of claim 16, wherein said axial outer surface of said elastic, annular seal member is one of being generally flattened, contoured, stepped and relieved, via surface finishing, after being fixedly retained within said recess.

18. The fuel staging valve assembly of claim 16, wherein said elastic, annular seal member is fixedly retained within a matingly contoured annular recess

located in said poppet member second diameter portion, said seal member being one of bonded, molded-in-place and cast-in-place.

19. The fuel staging valve assembly of claim 18, wherein at least one of said contoured recess and said seal member has, in cross section, an at least partial dovetail shape.

20. The fuel staging valve assembly of claim 16, wherein said elastic, annular seal member is comprised of a stiff rubber-based composition having an approximate 90 durometer hardness.

21. The fuel staging valve assembly of claim 16, wherein said contoured valve seat portion is one of gradually tapering, semicircular and of a double inwardly-tapering shape.

22. The fuel staging valve assembly of claim 16, wherein said predetermined diametral clearance spaces between said corresponding first and second diameter portions of said valve sleeve and valve spool are located in at least one of the mutually adjoining sleeve inner wall and spool outer wall surfaces.

23. The fuel staging assembly of claim 22, wherein said diametral clearance spaces function as predetermined, controlled, leakage paths through which a high pressure signal fluid can flow, via a fluid signal pressure conduit connected with said peripheral land cavity, from said high pressure signal cavity to adjoining areas of lower pressure between said valve sleeve and said valve spool via at least one further intermediate aperture and said diametral clearance spaces.

24. The fuel staging valve assembly of claim 23, wherein the percentage of fluid leakage is below about 2 percent of the total fluid flow within said assembly.

25. The fuel staging valve assembly of claim 16, wherein all axially movable components of said pilot valve are physically located upstream of said valve seat retainer member, in a direction opposite to the direction of the flow of fuel exiting from said discharge orifice, said axially movable components thereby being protected from combustion products produced during operation of said gas turbine engine.

26. The fuel staging valve assembly of claim 25, wherein said axially movable components include said valve spool, said pilot valve spring, said poppet member, said poppet spring and said seal member.

27. The fuel staging valve assembly of claim 16, wherein said pilot valve spring retainer includes an inner annular end portion, having a plurality of spaced radial passages, said retainer annular end portion, during certain predetermined operating positions of said staging valve assembly, being axially spaced relative to said pilot valve spool, while during other predetermined ones of such operating positions functioning as an outer axial stop member for said pilot valve spool.

28. The fuel staging valve assembly of claim 16, further including a fluid pilot supply conduit interconnecting said pilot and main valve spool central cavities at their respective valve gland areas; and a source of fluid signal pressure, connected with said pilot valve peripheral land cavity, and a fluid pressure signal conduit, interconnecting said pilot and main valves at their respective peripheral land cavities, for supplying said fluid signal pressure to said main valve.

29. In a gas turbine engine, a fuel staging valve assembly, for distributing fuel flow to a multiple zone nozzle therein, comprised of a pilot valve operatively interconnected with at least one main valve, each of said valves including:

a. a dual diameter valve housing;

b. a dual diameter cylindrical valve sleeve fixedly, sealingly and conformably received within said valve housing, said sleeve having a first diameter portion and a second diameter portion joined via an intermediate annular portion, with a peripheral land cavity being located between sleeve intermediate portion and an adjacent portion of said valve housing; and said first diameter portion having a peripheral, recessed, annular gland area with at least an axially spaced first plurality of discrete radial passages therethrough ;

c. a dual diameter hollow cylindrical valve spool, having a central cavity, conformably and slidably received within said cylindrical valve sleeve, said spool having a first diameter portion and a second diameter portion joined via an intermediate annular portion, with predetermined diametral clearance spaces being provided between corresponding adjoining first and second diameter portions of said sleeve and spool, thereby permitting a predetermined amount of fluid leakage therebetween, during operation of said pilot poppet valve; and an annular pressure signal cavity, interconnected with said land cavity, being located between intermediate annular portions of said valve sleeve and said valve spool;

d. a centrally apertured spring retainer fixedly received within said sleeve first diameter portion and closing one end thereof;

e. a valve spring, interposed between said spring retainer and said spool intermediate annular portion, for preloading said spool against said sleeve;

f. a centrally-apertured dual diameter valve seat retainer member having a first diameter portion and a second diameter portion joined via an intermediate radial surface portion, said retainer member first diameter portion being fixedly and sealingly received within an open end of said sleeve second diameter portion, with said retainer member intermediate radial surface portion being provided with an inwardly-directed, raised, central contoured seal seat portion adjoining said retainer member second diameter portion;

g. a generally cup-shaped closure member is fixedly and sealingly received on said retainer member second diameter portion and includes a central main valve discharge orifice;

h. a multiple diameter poppet member having interconnected first and second diameter portions;

i. a poppet spring, operatively interposed between said poppet member and a peripheral internal wall portion in said spool member second diameter portion;

j. a stiff, elastic, annular seal member, contoured in cross-section, fixedly retained within a mating contoured recess within said poppet member second diameter portion, having an axial outer surface adapted to sealingly mate with said raised valve seat portion of said valve seat retainer member;

k. a shim, fixedly abutting and acting on said retainer member intermediate radial surface portion;

l. a fluid pilot supply conduit interconnecting said pilot and main valve central cavities at their respective gland areas;

m. a source of fluid signal pressure connected with said pilot valve peripheral land cavity; and

n. a fluid pressure signal conduit interconnecting said pilot and main valves at their respective peripheral land cavities, wherein the improvement comprises:

o. said poppet member first diameter portion being yieldingly, slidably, received within an open end of said valve spool second diameter potion, with the axial movement of said poppet being restricted via a split retaining roll pin press-fitted relative to said valve spool second diameter portion but having a predetermined clearance relative to said poppet member;

p. said poppet spring axially biasing said poppet member toward said contoured seal seat portion, with said biasing being limited via said predetermined axial clearance, relative to said pin; and

q. said shim providing an initial, predetermined, sealing force, relative to said seal member axial outer surface, against said retaining roll pin, thereby

preventing fuel leaks at low fluid supply pressure, with said predetermined peripheral clearance, relative to said poppet member serving to limit the compression of said elastic member as well as allowing compensation for any seal compression set.

30. The improved fuel staging valve assembly of claim 29, wherein:

a. said elastic, annular, seal member is fixedly retained within a matingly contoured annular recess located in said poppet member second diameter portion, said seal member being one of bonded, molded-in-place and cast-in-place; and

b. said axial outer surface of said elastic, annular, seal member is one of being generally flattened, contoured, stepped and relieved, via surface finishing, after being fixedly retained within said recess.

31. The improved fuel staging valve assembly of claim 29, wherein:

a. said elastic, annular, seal member is comprised of a stiff rubber-based composition having an approximate 90 durometer hardness;

b. at least one of said contoured recess and seal member has, in cross-section, an at least partial dovetail shape; and

c. said contoured valve seat portion is one of gradually tapering, substantially semicircular and of a double-inwardly tapering shape.

32. The improved fuel staging valve assembly of claim 29, wherein said predetermined diametral clearance spaces between said corresponding first and second diameter portions of said valve sleeve are located in at least one of the mutually-adjoining sleeve inner wall and spool outer wall surfaces.

33. The improved fuel staging valve assemblies of claim 32, wherein said diametral clearance spaces function as predetermined, controlled leakage paths through which the high pressure signal fluid can flow, from said high pressure

signal cavity to adjoining areas of lower pressure between said valve sleeve and said valve spool via at least one further intermediate aperture and said diametral clearance spaces.

34. The improved fuel staging valve assembly of claim 33, wherein the percentage of fluid leakage is below about 2% of the total fluid flow within said assembly.

35. The improved fuel staging valve assembly of claim 29 wherein all axially movable components of said valves are located upstream of said valve seat retainer member, in a direction opposite to the flow of fuel exiting from said discharge orifices, said axially slidable components thereby being protected from combustion products produced during operation of said gas turbine engine.

36. The improved fuel staging valve assembly of claim 35, wherein said axially movable components include said valve spools, said main springs, said poppet members, said poppet springs and said seal members.

37. The fuel staging valve assembly of claim 29, said pilot valve comprising:

a. a multiple diameter valve housing having a central cavity and a fluid signal pressure input port extending into said cavity;

b. a multiple diameter cylindrical valve sleeve, said sleeve having multiple differing diameter sleeve portions, with one of said differing diameter sleeve portions having a peripheral, recessed, annular gland area with a plurality of discrete radial passages extending therethrough; and an intersection of two adjacent ones of said sleeve differing diameter portions serving as a seal seat portion;

c. a multiple diameter cylindrical spool conformably and slidably received within said cylindrical valve sleeve, said spool having multiple differing diameter spool portions;

d. a spring retainer slidably fixedly received on one of said spool differing diameter portions;

e. a pilot valve spring, interposed between said spring retainer and another of said valve spool differing diameter portions;

f. a generally cup-shaped, centrally apertured, valve seal retention member fixedly retained on another one of said valve spool differing diameter portions;

g. a generally cylindrical blocking member having one end attached to and movable with said another one of said sleeve differing diameter portions, with another end of said blocking member being sealingly received against a step portion of said valve housing under certain predetermined valve operating conditions while permitting communication between said housing central cavity and a peripheral land cavity located between said blocking member and said housing;

h. a stiff, elastic, annular seal member fixedly retained within said valve seal retention member, with a peripheral longitudinal portion of said retention member limiting the degree of compression of said seal member;

i. a shim, fixedly abutting and acting upon said valve seal retention member, provides an initial, predetermined, sealing force, relative to said seal member, against said valve seal seat portion; and

j. a centrally apertured disc closure member, attached to an exit portion of one of said two adjacent ones of said sleeve differing diameter portions, and including a central pilot valve discharge orifice.

38. The fuel staging valve assembly of claim 37, further including a fluid pilot supply conduit interconnecting said pilot and main valve peripheral land cavities; and a source of fluid signal pressure, connected with said pilot valve central cavity, and a fluid pressure signal conduit, interconnecting said pilot and main valves at their respective valve gland areas, for supplying said fluid signal pressure to said main valve.